SOUTHWEST ALASKA NETWORK (SWAN)
GEOLOGIC RESOURCES MANAGEMENT ISSUES
SCOPING SUMMARY

John Graham, Ph.D.
Colorado State University
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Executive Summary

A Geologic Resources Evaluation (GRE) scoping meeting was held in Anchorage, Alaska, on February 14-18, 2005, to discuss geologic resources management issues for the Southwest Alaska Network (SWAN), which includes Kenai Fjords National Park (KEFJ), Katmai National Park and Preserve (KATM), Lake Clark National Park and Preserve (LACL), Aniakchak National Monument and Preserve (ANIA), and Alagnak Wild River (ALAG).

The following mapping needs were identified for each park within SWAN. In general, the area is represented by bedrock geologic maps but more surficial geologic maps are needed.

- ANIA and KATM have both surficial and bedrock geologic maps
- Map OF-99-317, a digitized map of the Alaska peninsula, is scheduled to be published as USGS Bulletin 1969B and will cover ANIA and KATM
- KEFJ has a bedrock map but a surficial geologic map is a major need
- Detailed geologic maps are needed for the Exit Glacier area of KEFJ
- LACL will soon have a combined bedrock and surficial geologic map

Other map needs that were discussed focused on coastal needs, volcanic issues, fossil sites, potential areas of development, and unique geologic features.

The participants also prioritized the following geologic attributes.

KEFJ
1. Glacial studies
2. Coastal issues
3. Avalanche, rock fall, and flood hazards
4. River channel morphology

KATM
1. Volcanic hazards
2. Coastal issues
3. Seismic and tsunami hazards
4. Glaciers
5. Fossil theft

LACL
1. Drift River oil storage facility
2. Volcanic hazards
3. Pebble Creek mining proposal

ANIA
1. Volcanic issues
2. Water quality impacts and the effect on the distribution of organisms

Both bedrock and surficial mapping needs relative to each park were discussed with NPS personnel and cooperative partners representing the USGS, Alaska Volcano Observatory (AVO), academia, and a private consulting firm. Existing bedrock and surficial maps at a scale of 1:250,000 were identified with regard to digital quality, and additional mapping projects were discussed with regard to coastal needs and unique features specific to each park.

A session was held to specifically identify coastal research and mapping needs. In addition, special topics covered during the scoping meeting included: paleontological issues, archaeology, volcanism, earthquakes and Paleocene/Eocene slab windows, and lake level change in large lake systems.

Introduction

The National Park Service held a GRE scoping meeting for the NPS units in the Southwest Alaska Network in Anchorage, Alaska, from February 15 through February 17, 2005. The units addressed in this meeting included Kenai Fjords National Park (KEFJ), Katmai National Park and Preserve (KATM), Lake Clark National Park and Preserve (LACL), Aniakchak National Monument and Preserve (ANIA), and Alagnak Wild River (ALAG). ALAG was included in the KATM discussions.

The purpose of the meeting was to discuss the status of geologic mapping in the SWAN, the associated bibliography, and the geologic issues in the park. The products to be derived from the scoping meeting are: 1) digitized geologic maps covering the parks in SWAN; 2) an updated and verified bibliography; 3) a scoping summary (this report); and 4) a Geologic Resources Evaluation Report which brings together all of these products.

A brief overview of the Geologic Resources Evaluation program set the premise for the meeting, and this was followed with a presentation emphasizing the importance of geology in the NPS. A general discussion of park needs followed and participants decided to review these needs on a park-by-park basis.

Mapping Needs

A review of the available maps in the SWAN suggested that the area is well represented by bedrock geology maps, but not by surficial geologic maps at a scale of 1:250,000. Specific needs of the parks were addressed over the three days.

ANIA: Personnel from Aniakchak did not attend the scoping meeting, but representatives from the network and region helped define the monument's map needs. Two bedrock geologic maps combine to cover ANIA. Map I-1685 maps the Ugashik, Bristol Bay, and western part of Karluk quadrangles (Detterman et al., 1987, scale 1:250,000), and map I-1229 maps the Chignik and Sutwik Island quadrangles (Detterman et al., 1981, scale 1:250,000). The surficial geology has been mapped in maps I-1801 (Detterman et al., 1987, scale 1:250,000) and I-1292 (Detterman et al., 1981, scale 1:250,000).

Map OF-99-317 is an on-line map of the geology of the peninsula of southwestern Alaska at a scale of 1:500,000 that digitized most of KATM and ANIA. This map, a synthesis of all 1:250,000 scale maps, reportedly corrects a major stratigraphic error and rolls the bedrock and surficial geology into one publication. The map will be published as USGS bulletin 1969B. Some of the quadrangles were originally mapped at 1:63,360 and then compiled to 1:250,000.

Numerous fossil plant localities are interbedded with volcanic sequences within the park. Dinosaur footprints may be discovered along the Gates River. To identify these localities, more detailed mapping is needed in the Chignik D-1 quadrangle (Gates River area) and the Sutwik Island D-6 quadrangle.

A map of unique, or characteristic, geologic features was discussed for the parks. For ANIA, features noted included beach berms and beach ridges.

KATM/ALAG: Both bedrock and surficial geologic maps at a scale of 1:250,000 are available for KATM (Riehle et al., 1993, I-2204; Riehle and Detterman, 1993, I-2032). USGS Bulletin 1368B, the geology of the Iliamna quadrangle at a scale of 1:250,000 (Detterman and Reed, 1980), is now digital but the USGS has not published the digital upgrade. Optimistically, the map will be published this spring, 2005.

As previously mentioned, Map OF-99-317 is a digitized map of most of KATM. This map is scheduled to be published as USGS Bulletin 1969B.

Detailed bedrock mapping is needed in the Naknek Lake area. Specifically, the northwest part of I-2204 needs updating as Tertiary units have been missed. Flora within several hundred yards of Brooks Camp records a significantly different chapter in earth history than is represented on the map by Riehle and others (1993). The unit represents about 50 Ma that is not represented on the map. The unit has been interpreted as an incised valley-fill deposit and was missed due to the limited time that geologists were allowed to work when the map was done originally.

During discussion of priority mapping needs for coastal areas on Wednesday afternoon, a secondary priority for both KATM and LACL focused on mapping the bathymetry of large lakes as these are needed for paleo-ecosystem reconstructions and glacial/deglaciation research. A detailed map at a scale of 1:24,000 of the Brooks Camp area and the road to the Valley of Ten Thousand Smokes would also be useful.

Hildreth and Fierstein (2003) have published a new geologic map of the Katmai volcanic cluster, map I-2778. The map is a digital geologic map and focuses on volcanic units in the Valley of Ten Thousand Smokes. More mapping of the viewshed may be needed, especially in the Mt. Katmai B-5 quadrangle. A new volcanic hazard assessment map has been published as OF-00-489. This map has not been digitized and shows only hazard units and not geological units.

A map of unique, or characteristic, geologic features was also discussed for KATM. Such a map could include features as geothermal features, caldera lakes, beach berms, beach ridges, terminal moraines and related lake system, and 1964 earthquake features. This map would be useful as a management tool or interpretive aid.

KEFJ: USGS map OF-99-18B (Bradley et al., 1999, scale 1:250,000) is digital but mostly maps bedrock. This map is a digital copy of the paper copy (OF-99-18A) that was printed simultaneously. The map was compiled from 1:63,360 scale maps that are housed in the Anchorage office of the USGS (http://geopubs.wr.usgs.gov/open-file/of99-18/svgeol_meta.htm). The Seward and Blying Sound quadrangles mapped together by Tysdal and Case (1979, scale 1:250,000) is also a bedrock map. This map is digitized but apparently the publication of the digital version is in limbo. Map I-1019 (Magoon et al., 1976, scale 1:250,000) maps bedrock, but the Quaternary is undifferentiated.

There is a major need for more surficial mapping in the KEFJ area. Karlstrom's Professional Paper 443 (1964, scale 1:250,000) may contain some useful surficial mapping since Karlstrom was a surficial geologist, but there are no plans to digitize the map and the map doesn't cover the park.

The major mapping need for KEFJ is for more detailed mapping (scale 1:24,000) in the region of Exit Glacier because of visitation and future development potential. In order of priority, the park would like detailed mapping of Seward A-7, Blying Sound D-8, and Seward A-8 quadrangles. Most specifically, they would like the upper northwest section of Seward A-7 and the upper northeast section of Seward A-8 mapped.

All the parks were interested in better Digital Elevation Model (DEM) images. However, if better DEMs are not possible, KEFJ expressed an interest in cross-shore (i.e., shore normal) polygon mapping of shorelines. With regards to coastal mapping, a shifting shoreline is not a major issue for KEFJ.

Hazard zones related to tidewater glaciers could be mapped. The glaciers are receding and hanging glaciers and icefall are localized hazards, but a map could show local areas of potential hazards. Interest was also expressed in having a map of all the mining adits. The adits have been inventoried but have not been combined onto a single map.

The few wetlands in KEFJ have been mapped, The park contains salt marshes, lagoon and lake systems without surface flow in or out, and submerged terminal moraines associated with the coastline. These features could be compiled into one map.

KEFJ is also first in line for an ortho-corrected image map that should be completed by the end of the summer, 2005. This map will have a 4 meter multi-spectral resolution so that features such as roads, building, and trails can be mapped. The question was raised as to the maps usefulness to map geology.

LACL: Ric Wilson and Tom Bundtzen are putting the finishing touches on a new combined, digital bedrock and surficial map of LACL at a 1:250,000 scale. Ric's map will supercede MF-1114A of Nelson and others (1983) and include the Lake Clark quadrangles on the Lake Clark sheet, the Kenai quadrangles on the western edge of the Kenai sheet, and the Seldovia D-8 quadrangle on the Seldovia sheet. His map will merge with the geology in the Iliamna D-1 through D-6 quadrangles mapped by Detterman and others (1968). Tom is mapping the Lime Hills quadrangles on the Lime Hills sheet and the Tyonek A-8, B-8, and C-8 quadrangles on the western edge of the Tyonek sheet. When complete, the LACL map will include the park and an area around the park.

The new map will include features related to the receding glaciers. The map may be used to quantify glacial loss by comparing with 1950s vintage air photos. In addition, Tom has submitted samples from the moraines interpreted to be the Wisconsin glacial maximum. If the sample yields a radiocarbon date, it will be the first date ever on this unit.

A power line to the Pebble Creek mining operation has been proposed to pass through Lake Clark pass, and if a road is built, a detailed geologic map of the area may be needed. The power line would intersect a major fault trace and would be located in an area of avalanche potential.

Two mapping needs were identified regarding coastal mapping in LACL: 1) large lake bathymetry maps, and 2) shoreline mapping. As with KATM, large lake bathymetry maps are needed for paleo-ecosystem reconstructions and glacial/deglaciation research. Detailed shoreline mapping may identify sources of gravel, whether on park or private land, that may be needed to support the development of the Pebble Mine.

Volcanic hazard assessment maps have been published for the Redoubt and Iliamna volcanoes, but these maps are hazard maps, not geology maps (Waythomas et al., 1998; Waythomas and Miller, 1999). The maps are not in digital format and are for illustration purposes only. They show hazard units and not geologic units. There are no metadata provided nor are there any registration tics on the maps. The Alaska Volcano Observatory is in the process of generating new digital maps of volcanic areas but these will not be completed for three to five years.

As with KATM, participants expressed interest in a map that would combine unique, or characteristic features, within the park. Features could include cold springs, warm springs, mineral licks, terminal moraines and related lake system, and 1964 earthquake features.

Geologic Attributes in SWAN

Geologic attributes that might require a baseline inventory and monitoring were discussed on a park-by-park basis in the following order:

KEFJ Geologic Attributes: SWAN is funding glacial extent monitoring on a decade scale. Dorothy Hall (NOAA) is working on this and has finished KEFJ. She has interpreted satellite Landsat images and changes and will deliver a report and GIS shape files. Resolution is 30 meters. KATM is her next park. The USGS also has a project replicating Higgin's 1912 oblique photos.

It was noted that when digitizing ice extent on a 1950s topographic map, the boundary between the snowfield and ice can be a fuzzy line. Yet, comparing 1950s photos with today's images is a good place to start. A 1:63,360 scale was recommended.

At Exit Glacier, the terminus is annually mapped from the ground or the air. Snow pits for snow profiling have been excavated over the past couple years and last year, a weather station was erected on the glacier. While the glaciers may be mapped in two dimensions, the depth, and thus the volume of the glaciers, needs more research. There has been some laser profiling on Exit and Harding ice fields that record some volume changes. One coring project drilled 15 meters into the ice and got stuck. Ice glands in the snow break core augers. Some spectacular topography might exist beneath the ice fields. For example, Harding Ice field could cover Yosemite Valley.

The glaciers are dynamic systems with snow building up on top with increased precipitation and then melting back in a forward-retreat cycle, possibly at 1000-year intervals. Each tidewater glacier in the fjords is probably different. Cataclysmic breakup occurs when glaciers recede.

More research is needed on a mass balance scale. The geology beneath the glaciers is unknown. There may also be a need for more data about glacial outwash plains and potential impacts to facilities and planned facilities. Facilities could be buried by fluvial debris flows and flooding. Big rain events can cause massive flooding so that flood issues are directly tied to glacial monitoring. Flooding, habitat sustainability, fluvial processes, and lacustrine systems are all tied to the glaciers.

Dust from as far away as China was discussed as a potential problem. Dust can carry toxic chemicals and bacteria that may impact water quality. Harding Ice field could have more than usual chemical accumulation but nobody is studying this potential contamination. Since ice cores have a resolution on a yearly basis, whereas lake sediment data are good on the decade level, ice core studies have the potential for detailed analysis of chemical buildup.

Avalanche and rockfall potential is a primary hazard in all the parks. Ice falls are also a potential hazard for visitors camping at the base of outwash plains.

Shelley Hall, KEFJ, presented the following list of issues/attributes:

- Seismic: some work is being done in KEFJ on crustal movement. Dr. Jeff Freymueller, University of Alaska, Fairbanks (UAF) established one station measuring both vertical and lateral movement on Exit Glacier.
- Mining: abandoned hardrock gold mining sites present safety and hazard issues at KEFJ. Presently, there is one unpatented mining claim, the Waterfield claim, and it is under contest action. Arsenic and mercury have been discovered in at least two locations: Beauty Bay and Surprise Bay. Arsenic has been found in Beauty Bay and in a settling pond. The park owns the mining claim but private land adjoins the hazardous site. Beauty Bay contains fifty drums and arsenic in tailings. Exposed blasting caps were also in Beauty Bay before Bud Rice blew them up. Five claims in upper Surprise Bay have tailing piles containing mercury. The mercury is not from bedrock but used for amalgamation of gold.

Mine adits have been inventoried and are awaiting disposition of land and closure in which the debris will be removed. Some sites could be interpretive sites. Contaminants from mine tailings have the potential to contaminate surface water but they have not yet moved into surface water. No groundwater problems were noted.

- Caves and karst: a significant number of sea caves and adits are now at sea level. In a James Lagoon cave, lake varves have been discovered. Natives have placed masks in the back of some of these caves. The caves do not seem to be a habitat for bats or large land animals.
- Fossil resources: (see the section on *Paleontological Issues in Parks*)
- Hillslope processes: regarding avalanche potential, the entire Kenai area is composed of “crumbling mountains”. Mass-wasting is visible and perhaps more could be done in interpreting hillslope processes. The park doesn’t have a visitor center with exhibits so there is not a lot of interpretation except from private tours. The area is billed as the “Gateway to KEFJ” so boats generally have an interpretive program.

KATM Geologic Attributes: Alan expressed the hope that Bruce Molnia will study the tidewater glaciers at KATM. Glacial extent at KATM can be compared using photos from the 1920s. Glaciers are the source of water for the park. Water supply is becoming an issue as glacial systems become non-glacial systems. Issues that need to be defined include the pulse of flow, rate of change, sediment input and removal, biological and ecosystem change, and stream flow. Accessibility and cost preclude monitoring using traditional USGS gauging stations.

Unusual glacial features in KATM include two glaciers formed in Novarupta crater since 1912. More research needs to be done on these glaciers. There is also a growing lake which could burst by 2050 causing an outburst flood.

Permafrost is an issue in the northwest part of KATM. Permafrost could be mapped. The permafrost is discontinuous and marked by the advance of spruce forests.

Chris Nye looked at thermal springs along the coast, but he did not do a systematic study.

Windstorms pick up great quantities of ash and redeposit it.

Theft and destruction of fossil resources are an issue at KATM (see *Paleontological Issues in the Parks* below). Layers of Jurassic ammonites along the coastline tempt visitors. Fossils are archived but there are too many to collect all of the specimens.

Visitors and airplane landings are impacting cryptobiotic crusts in the Valley of Ten Thousand Smokes. Foot traffic is also causing erosion of the river bank near Brooks Camp.

The Alaska Volcano Observatory has published a volcanic hazard assessment for Katmai in which volcanic resources are addressed. Seismic monitoring is ongoing with 22 seismometers in KATM.

Underground contamination from diesel and gas leaks at Brooks Camp and underground fuel spills from multiple sources along coastlines is an issue in KATM. Not all of the contamination sources have been removed. The following day, it was noted that these underground spills are now a non-issue since standards have been reached.

LACL Geologic Attributes: LACL contains many smaller glaciers. Small glaciers present a mapping problem. Landsat cannot delineate small glaciers as easily as larger glaciers, yet smaller glaciers react more quickly to climate change than do large glaciers. A good historic photo record of the glacier at Lake Clark pass exists.

Mining operations that might impact LACL were discussed. Small abandoned mining operations such as the Bowman Mine, Kasnik Creek mine, and the Kontrashibuna mine have been mapped. The Portage Creek placer gold mines were "small time" and are currently inactive. The iron and magnetite claims on hillsides east of Lake Clark have long been abandoned. The Pebble mine, however, is in the permitting process. The operational target for this hardrock gold and copper mine is 2010. This mine has the potential to be as big as the Bingham Mine in Utah. The mine is near a world-class rainbow trout river. The operating company is Northern Dynasty from British Columbia. As of the scoping meeting, all potential resources have been inferred.

A volcanic eruption could impact the Drift River Storage Facility and cause leaking oil to impact Cook Inlet and the LACL coastline. The severity of the impact would depend on the time of year and weather conditions. Participants noted that chronic contamination from the site might be in progress and the Cook Inlet Residency Advisory Council is doing some monitoring. There is no body of conclusive information suggesting contamination, but from the age of the facility, contamination is probable. An additional storage facility may have to be built. Private land is located between KATM and LACL upon which to build.

An abandoned cannery off the coast of Lake Clark is leaking hydrocarbons. Accumulation of hydrocarbons has been noted in sediments and invertebrates. As the cannery is on private land, the NPS cannot do anything about the contamination.

Slope failure and rock fall is mostly a problem where there are visitors.

The surface level of Lake Clark has been dropping for twenty years. This affects navigation, salmon spawning, and access by floatplanes. A net loss of water to the system occurs because precipitation doesn't keep pace with glacial melting and lake level drop. Less discharge from lakes has caused a dramatic change in river channel morphology. Braided glacial river systems are now vegetated because of lack of flow and flood events that scoured their channels in the past. Historical photos can be used to verify change on a large scale and can be used to help plan a monitoring program.

The wetland system is also shrinking. In the north, the effects of drying can be clearly seen. Foothill lakes around Lake Clark that drain to the west are lower in elevation today than in the past. The volume of riparian wetlands is diminishing.

A discussion of fossil resources was deferred until the next day. The management issues pertaining to paleontological resources are discussed in the *Paleontological Issues in the Parks* section below.

Caves, which are only about thirty feet deep, can be found along the coast. North Bay was an old fjord and evidence of sea stacks and caves can be seen. Some of the caves contain aboriginal paintings.

Lake Clark lies on a fault line. Fourteen seismometers form a monitoring network for the park's volcanoes.

The following table summarizes the geologic attributes of each park and lists these attributes in order of priority, to the level at which park personnel felt comfortable.

Park	Attribute	Priority
KEFJ	Glacial studies: volume and mass balance needs	1. Glacial studies and coastal issues
	Hazard Assessment: seismic, tsunami, flooding, avalanche & rock falls in Exit Glacier area	2. Coastal issues
	Disturbed lands/mining: Hg, As	3. Avalanche / Rock fall, flood hazards, river channel morphology
	Interpretation: information to visitors	4. Disturbed lands/mining
	Refugia	
	River channel morphology	
	Coastal issues	
KATM	Glaciers: repeat photos/ glaciers forming	1. Volcanic hazards
	Fluvial processes: glacial outflow to non-glacial period	2. Coastal issues
	Fossil theft: inventory, theft, research	3. Seismic & tsunami hazards
	Wind redeposition of ash	4. Glaciers
	Cryptobiotic soil	5. Fossil theft
	Coastal	
	Volcanic hazards	
	Seismic and tsunami hazards	
	Need for more baseline information to decide on priorities	

	No geologist on staff	
LACL	Glacial: many small lakes	1. Drift River Oil Storage facility
	Abandoned cannery: fuels & hydrocarbons	2. Volcanic hazards
	Drift River Oil Storage facility: linked to volcanic hazards	3. Pebble Creek mining issue
	Lake Clark water level dropping	
	Volcanic hazards: Iliamna & Redoubt	
	Pebble Creek mining issue	
	Fluvial changes	
	Johnson River mine	
	Coastal issues	
ANIA	Paleo resources	1. Volcanism
	Volcanism	2. No other priorities were listed since ANIA was not represented
	Coastal	
	Shrinking of snow fields in calderas with regard to river discharge & salmon sustainability (river dynamics)	
	Eolian processes and dust (ash) distribution with impact on vegetation	

Coastal Geologic Mapping Program

Rebecca Beavers, NPS-GRD, presented an overview of the coastal mapping program's work in progress. Mapping needs for a coastal map include:

- Anthropogenic mapping units
- Subtidal mapping units
- Supratidal mapping units
- Intertidal mapping units
- Coastal/riverine mapping units

A coordinated effort of all partners is needed to produce seamless coverage from emergent to submergent areas. Surface geology and geologic framework are needed for a coastal inventory in order to document response to sea level change.

Including large lakes, ninety shoreline parks need coastal mapping to a scale that will yield needed information. The correct scale is critical and different parks will have different scales. For example, Cumberland Island National Seashore will require a different scale than KEFJ.

Coastal parks are divided into two types: barrier island types, and coral-volcanic-marine types. Several examples described the type of mapping needed. These examples included: Cape Hatteras, Canaveral National Seashore, Kona Coast, Kaloko-Honokoham, Virgin Islands, and Buck Island Reef National Monument.

Another function of the coastal mapping group is the Coastal Vulnerability Index Assessment (CVI). A CVI relies on existing data for sea level rise analysis. Geomorphic variables are used in the study to produce a report, metadata, and shape-files. A CVI map shows vulnerability ratings of very low, low, moderate, high, very high. Olympic National Park was used as an example.

Coastal GIS Themes

Joel Cusick presented an overview of the theme sheet for coastal themes in AKRO GIS. The region has duo-positive photos at a scale of 1:12,000 that are about ten years old. The photos are tidally coordinated (near-shore to subtidal).

ANIA is in the CVI. KATM has 92 photos overlain onto marine charts. The park boundary is recognized in mean high water. Ten geomorphic variables are mapped along the Kukak Bay coastline but mapping resolution is not good. Joel mentioned that there is extensive ESI coverage for KATM.

The marine shoreline at LACL has across shore and along shore delineation of geomorphology and slope. A robust data set allows a possible 5-acre minimum mapping unit. An 11 x 17 paper product has been digitized into the index.

KEFJ has 114 photos taken over three to four years with a horizontal accuracy standard of 20 meters. Resolution can be to 1-2 meters.

Three shoreline classifications schemes were noted. Both line based and polygon based classification schemes are available. Harper Shore Zone currently is quite active and can do miles of coastline in a timely manner. Daniel Mann (1996) has written an article titled *Shore-Zone classification of KATM and KEFJ* that is available through the Alaska Quaternary Center in Fairbanks. Beach areas of priority are identified with regard to emergency oil spill response in *Shore Zone Mapping Data, Katmai, Alaska* by Coastal and Ocean Resources, Inc. and are available on line at www.coastalandoceans.com.

Coastal Issues

Coastal issues addressed with respect to SWAN fell into the following categories:

1. *Acreage of coastal lands*: Issues of ownership and wilderness

2. *Length of shoreline*: This includes beach, inlet, estuarine, and definition of the measurement method. Participants noted that the Alaskan shoreline has been measured.

3. *Existing monitoring programs*: There are monitoring programs for shoreline change, sea turtles, and threatened and endangered species.

4. *Existing inventories*: Soils, vegetation, submerged vegetation, benthic habitat, surface geology, bedrock geology, fauna, and landforms. Subtidal mapping was noted as a big need.

5. *Ground control points*: Few GIS data points have been defined.

6. *Digital elevation data (DEM):* Data includes date collected, method used, and resolution. DEMs are complete but poor because they are based on 1950 mapping.

7. *Coastal engineering projects*: Data would include location and description, date constructed, monitored, special use permit, and compliance for hard structures, soft structures, and dredge areas. The question was raised as to projects in the network, but the answer was not clear. If there are projects, they are probably on inholdings. The mouth of the river has been dredged at Brooks Camp.

8. *Shoreline change data:* Data would include ocean and estuarine historical data, hurricane and other storm paths, and "hot spots" such as chronic erosion areas. Photos could be used to collect data. The 1964 earthquake had a profound effect on the shoreline.

9. *Seasonal closure for wildlife protection*: KATM has a couple areas for bear viewing and some very small areas around Brooks Camp. KEFJ has large areas closed to visitors to protect sea lion habitat adjacent to the park boundary.

10. *Off-road vehicles*: SWAN is dealing with the impacts of off-road vehicle use. It is becoming a growing issue, especially in salt marshes.

11. *Personal watercraft*: KEFJ has some issues with personal watercraft.

12. *Maintenance concerns*: Roads, boardwalks, utilities, and facilities. KEFJ has issues with the eroding shoreline and with cabins on the coast. Facilities and road erosion are

concerns at Brooks Camp. Docks at Lake Camp and Naknek Camp are concerns at LACL.

13. *Unique (characteristic) geomorphic features*? These features were covered in the section on *Geologic Attributes*.

14. *Marine resources*: A contentious relationship with the state exists over where the park boundary lies, i.e., at mean high water or not. Harbors haven't been decided, especially up rivers. New shoreline and islands emerge as glaciers melt. No coordinated tide data system exists. No tsunami warning system exists for small communities along the coast. Only broad-brush wave and current data from the mid-1980s are available. As for bathymetry, the NOAA data has not been put into vector format. Lake Clark bathymetry needs to be mapped as with other large lakes in the park.

15. Cultural resources: Shipwrecks and caves. There may be some submerged caves but no data are available.

16. *Pipelines and other Anthropogenic features*: A power line may be installed over Lake Clark pass. A hydrocarbon pipeline is in Cook Inlet.

17. *Management plans*: This is a broad category. There are management plans that cover coastal resources.

18. *Storm, tsunami, oil response plans*: A unified state and federal plan covers Alaska. Presently, the plan focuses on areas that can be helped. More information is available at www.geographicresponsestrategy.com

19. *Recreational impact areas*: Some of the coastal uses include surfing, wind surfing, plane landings on beaches, vehicles in salt marshes, tour boats, and kayaking. Recreational activities impact campgrounds, nesting coastal birds, and salt marshes. Plane landings compact sediment and vegetation. Erosion occurs from tour boat traffic in tight inlets (there are no "no wake" zones). Harvesting glacial ice impacts seal habitat.

20. *Water quality issues*: Some issues involve Brooks Camp and drums at Michigan Point. KATM has areas being monitored from the Exxon Valdez oil spill. KEFJ has abandoned mine issues and some contaminated soil sites.

21. *External threats*: External threats include installation of mooring buoys that could give rise to floating hotels or fuel barges, fishing with regard to crab pots in inlets and illegal on-shore storage, and bear viewing in coastal areas.

Discussion of coastal research and mapping needs led to the following table:

Research Needs	Mapping Needs
Updated shoreline	Updated shoreline to useable scale for specific hot areas in each park. KATM: intensive mooring sites, Kukak Bay, geographic harbor, bear viewing areas.
Better DEM coverage; image acquisition	Better DEM (and Lidar) – need ground control
Looking at changing bathymetry in modern fjords and tying to history of tidewater glaciers at KEFJ	Imaging now stops at park boundaries. Identify adjacent high priority areas.
Sedimentation rates in tidewater glacier bays	Cross-shore polygon mapping of shorelines

	if can't get Harper Shorezone Classification to deal with 30 feet tides
Glacial volume changes	National wetland inventory (nothing been done on this issue)
Uplift and subsidence rates along coast	Bathymetry maps. Unknown how far offshore can go (money issue). Bathymetry of large lakes, too.
Studies in paleo-ecosystems in prehistorical watersheds	Highly focused glacial terminal photos have yet to be registered and used to identity glacial terminus (Terminal Recession Research maps)
Groundwater chemistry and other changes in water chemistry related to permafrost, etc.	Watershed maps – old and new comparative maps. Change in storage area and potential flashy flood events; also, impact of increased vegetation and flooding (abundance and distribution)
Potential flood events with deglaciation and changes in vegetation cover (abundance & distribution)	Aerial photographs on specific intervals (i.e., 10 or 20-year interval)
Rate at which vegetation can be reestablished in glacial areas (25-30 years in Alaska)	
Deglaciation and impact on salmon colonization in newly exposed areas	
KIMU (*Killetz' murrets*) habitat change as glaciers recede	

First priority for all parks was for better DEMs, although DEMs are costly. Lidar flights could try to coordinate with NOAA flights. Second priority for KEFJ was cross-shore (shore-normal) polygon mapping of shorelines if DEMs are unobtainable. Second priority for KATM and LACL was bathymetry maps, especially lake bathymetry.

Paleontological Issues in the Parks

Tony Fiorillo of the Dallas Museum of Natural History presented the paleontological issues in SWAN. In the last twenty-five years, paleontologists have made significant discoveries in Alaska. A duckbill dinosaur found along the coast of ANIA was the first record of dinosaurs in southwest Alaska. A horned dinosaur bone from the *Pachyrhinosaurus*-rich Kikak-Teqoseak Quarry along the Colville River in northern Alaska, north of the Brooks Range, relates to the findings in ANIA and can be linked to other sites in Alaska.

Today, biodiversity decreases from the equator to the poles. From research on the North Slope, this same pattern shows up in the fossil record and raises the question, "What were dinosaurs doing up here?" Unlike migrating mammals, like caribou, dinosaurs did not maintain proper body weight to support a migration theory. Rather, they were year-around residents. How did they survive?

Paleontologists know that the dinosaur carnivores that roamed Alaska were different from those in Montana. For example, Troodan had bigger eye sockets than carnivores to the south. Perhaps his eyes had adapted to lower angle light conditions. Northern Alaska was farther north than it is now although the peninsula was located near the latitude it is today. More research on Alaska's dinosaurs, including research in SWAN units, may help answer some of these questions.

ANIA: A whole ecosystem is defined at ANIA. A 3-toed Ornithipod of Campanian-Maastrichtian age was found in the Chinook

Formation along with thirteen upright fossil trees. The trees looked like gymnosperms with diameters less than 20 centimeters and spaced 2-6 meters apart. Apparently, the 35-foot long animal was walking between the trees. Angiosperm leaves were found in the understory. The angiosperms had about 10% leaf-damage. The data support an ecosystem wherein small herbivores ate angiosperms while bigger animals ate the gymnosperms.

The Ornithipod was the first record of Cretaceous dinosaurs for western Alaska. Because it was found along the coast, paleontologic resources may relate to coastal issues. Large polygons in ANIA remain to be investigated for fossils.

Paleogeographic reconstructions show ANIA at about the same latitude as today. Temperatures in Alaska 70 million years ago were like Southern Alberta today. The climate was cool but warmer and still supported ice fields. Data from ANIA might help define the origins of Beringia.

Troy Hamon was on the river trip with Tony at ANIA and knows where the plants are located. Because the volcanic eruptions can be dated, whole ecosystems can be described. Some of the localities are several miles from the river.

KATM: Early Tertiary fossil leaves have been discovered at Brooks Camp and may indicate an unmapped formation about 40 million years old. Visitors steal these fossils so that these paleontologic resources present law enforcement and monitoring issues. Mapping of these deposits suggests that the sediment was deposited in an incised valley fill sequence.

In the Valley of Ten Thousand Smokes, the Jurassic Naknek Formation underlies volcanic ash. Most of the Naknek Formation represents marine deposition of siltstone and shale, but at the top of the falls lies a harder sandstone deposited in a delta system. A fossil bone was found in the sandstone. The thickness of the bone suggests that it was once part of a dinosaur. This bone is the first Jurassic dinosaur bone found in Alaska and offers a great opportunity for interpretation.

LACL: Ammonites are abundant at fossil point. There are no chisel marks on the fossils, which suggests that if they are being stolen, they are first weathering out of the rock. Fossils weathering out of the rock become a state issue, not a NPS issue.

A fossil tree has weathered away along the lake edge, but nine more fossil trees have been found. A mid-Tertiary forest ecosystem remains to be investigated. The locations could be mapped and there is an opportunity for interpretation.

KEFJ: Although Exit Glacier covers rocks that aren't believed to have great fossil material, a limestone block about fifty feet outside the park contains a number of invertebrate fossils from the Permian. Fusulinids are abundant. The fusulinids, gastropods, and oolites represent a sub-tropical environment and suggest a story of tectonics and plate accretion. In addition, spongiforms and hydrocarbons have been found together.

In summary, SWAN has enormous fossil resources in each park. Each park needs a baseline inventory of fossil resources in order to develop monitoring and interpretive programs.

During the discussion period that followed, Tony explained that the Dallas museum got involved because there is limited space to house collections in Alaska and nobody in the Fairbanks Museum could incorporate the material.

Tony explained that on the black market, vertebrate fossils bring the highest price while leaves are slightly greater in value than invertebrate fossils. From a law enforcement viewpoint, then, it is the vertebrate fossils that get stolen. Some lodge operators advertise "fossil viewing" to Fossil Point. These operators might help the NPS discourage theft. Fishermen and seasonal visitors seem to collect the most as fossils are sometimes found stacked behind cabins.

Archaeology and the SWAN Parks

Richard VanderHoek discussed archaeology related to the SWAN. At ANIA, distinct channels from the outburst flood that resulted from draining the ANIA caldera can be mapped using air photos and cores. The lowest organics were dated at 1850 years BP so the flood occurred between 1800-1900 years BP. The first occupation of the area is 2000 years BP and then occupation seems to be interrupted for 200 years.

In Aniakchak Bay, flood channels are outlined by alders. The front blowout berm is dated to be about 550 years BP from a tree in front of the berm. Richard presented a cross-section of the berm system and explained the distinct set of vegetation patterns and how the berm system chronicled ancient events like massive pyroclastic flows that occurred about 3400 years ago.

Amber Bay, in comparison, was not impacted by pyroclastic flows prior to 3400 years BP. In fact, the bay is only 800-900 years old so it wasn't even around during the pyroclastic flows that impacted the villages around Aniakchak Bay. An onlap event, however, found in a blowout berm, represents a tsunami overlap event dated at 650-660 years BP. Evidence was also found for a tsunami event about 700-800 years BP. Cultural sites are vacant of people during this time.

Just north of ANIA River in the ANIA Bay area, the Cabin Bluff exposure has 3.5 meters of Holocene sediments. Pollen extracted from the soil can be related to volcanic ash horizons.

Recent Volcanism, AVO Research & Monitoring Program, Mapping Products in LACL, KATM, ANIA: a Quick Tour

Christina Neal presented a brief overview of the AVO and its research related to SWAN. Alaska is the most volcanically active state with 43 volcanoes in the Aleutian Arc alone. There are five historically active volcanoes on park land, and three others in the parks are associated with strong gases or earthquakes. In the last 10,000 years (Holocene), over thirteen volcanoes have been active. Three caldera-forming eruptions have already occurred in the Holocene. Novarupta is the Earth's largest eruption since 1815.

LACL: The two major volcanoes in LACL are Redoubt and Iliamna. Redoubt is a stratovolcano rising 3108 meters above sea level. The Drift River Oil Terminal is located 35 kilometers downstream at the mouth of the river. In 1989-90, the volcano caused over $160 million in damages. Mt. Redoubt is home to three Holocene debris avalanches. A lava dome is growing in the ice-filled crater and could founder into a hot avalanche down the north slope.

Mt. Iliamna is also a stratovolcano but has no historical eruptions. Six lahars have occurred in the last 2400 years (with or without associated eruptions). There is an active fumarolic field and a Plinian eruption (like St. Helens) occurred in the last 7,000 years. A magmatic intrusion began to be emplaced in 1996, but no eruption followed. Mt. Iliamna presents a significant debris flow and avalanche hazard.

KATM: KATM is extremely active seismically with thousands of earthquakes. Over twelve young volcanic centers are in KATM. Should a 1912 eruption occur today, the extensive fallout would impact commerce and air traffic from Fairbanks to Seattle and points east. Mt. Mageik and Mt. Martin have no confirmed historical activity, but they have robust fumerole activity. Mt. Trident, a three-peaked stratovolcano, has been historically active. Eruptions that occurred from 1953-1974 would present significant disruptions to air traffic today. The Snowy Mountain volcanic center, Mt. Denison, and Mt. Steller are unknown as to eruption history but are alive in the northeast part of KATM. A crater lake occupies Mt. Douglas volcano that sits at the mouth of Cook Inlet. The water in the lake is quite acidic with a pH of 1-2.

Hildreth and Fierstein (2000) produced a map of KATM but the map does not follow quadrangle boundaries (http://pubs.gov/imap/i2778). Rather, the volcanic deposits are mapped.

ANIA: The last eruption in ANIA was in 1931. Ash from the first eruption circumnavigated the globe and resulted in thick (40-100 m) ash flow deposits. The seismic activity from this volcano may have generated a tsunami on the other side of Bristol Bay. Approximately 1700 years ago, the lake that filled the crater drained catastrophically leaving evidence such as bedrock scars. The discharge rate was greater than the rate for the Amazon River. There is no good clue for the cause of breaching. Over the past 3500 years, ANIA has had multiple explosive, effusive eruptions. More than 24 eruptions have occurred since the caldera formed. Two geologic maps are in progress. One covers the crater; one focuses on ANIA.

ANIA is a quiet place compared to KATM. There are a few “tremor bursts” but relative to KATM, there is not much seismicity. Carbon dioxide, expelled from magma at depth, bubbles to the surface through springs.

All volcanic hazards are represented in SWAN. The AVO publishes volcanic hazard assessment maps for the volcanoes that can be downloaded from their website: www.avo.alaska.edu. The AVO provides volcanic monitoring and early warning and establishes seismic networks consisting of about 5-6 stations around each volcano. At KATM, 20-30 stations are needed to capture all of the volcano. ANIA is a difficult site to monitor since wind abrasion destroys equipment.

The data are used in the following ways:
- Research
- Archived
- Made available to the public in real time using webcam
- Hazard assessment publications for lay audience
- In a few years, AVO is planning to remap Cook Inlet related volcanics into GIS
- Modeling volcanic processes: tsunami, ash falls, lahar, calders formation, etc.
- Petrologic studies to understand volcanic plumbing
- Tephra deposits used as regional markers (many applications)
- Using seismic and geodetic data to infer magmatic processes and subsurface structure.

During the discussion, participants noted that there is no systematic study to monitor lake levels in calderas. Depending on the parks’ needs, AVO will collect samples from the bottom (Griggs’ samples have been lost) and do some bathymetry.

Presently, no written protocol for a response to an event is available. AVO is considering something like a “response science plan.” The Interagency Response Plan warns aviation during volcanic ash episodes. The NPS hasn’t been involved in discussions for interpretation and they probably should be. As AVO begins their re-evaluation of Mt. Redoubt and Mt. Iliamna, they should plan with the park to identify what the park may want. Janet Schaefer is the point person for GIS.

Janet gave a brief overview of how to access AVO data from their GeoDEVA (Geologic Data Evaluation of Volcanoes in Alaska). Go to the AVO website and click on “DEVA”. This is a live database driven site and a variety of topics are available to search. The data can be downloaded to excel spreadsheets, for example. Images, a bibliography, and GIS data are available.

Earthquakes and Paleocene/Eocene Windows and Geology of KEFJ

Peter Haeussler, USGS, presented a general tectonic overview of plate tectonics and Alaska. Alaska has more earthquakes than the rest of the United States combined. Alaska is home to three of the seven largest earthquakes in the world. Since 1900, there has been at least one M8 or greater earthquake every 13 years and one M7-8 earthquake each year. Slippage along plate margins causes earthquakes and the size of earthquakes is related to the size of slippage. Earthquakes show the location of the subducting plate.

The 1964 earthquake is the second largest earthquake over recorded. Shaking during this M9.2 earthquake lasted 4.5 minutes. The rupture area was approximately 150 x 800 kilometers (90 x 500 mi) compared to the 1.6 x 1.6 kilometer (1x 1 mi) earthquake that was felt on Wednesday, February 16, 2005, in Anchorage. The 1964 earthquake played an important role in the acceptance of plate tectonics.

As a result of the 1964 earthquake, large areas underwent both uplift and subsidence. At Portage, subsidence of two meters caused the trains to only run when the tide went out. Coastal forests died where marine waters flooded tree roots

At KEFJ, subsidence that occurred during the 1964 earthquake killed trees and left other evidence. However, inter-seismic subsidence also occurred and drowned cirques. Not much research has been done regarding this inter-seismic subduction but one hypothesis relates subsidence to "subduction erosion" wherein chunks of the overriding plate are removed by the subducting plate so that the overriding plate subsides.

A recurrence interval for a "megathrust" event like the 1964 earthquake is about 400-700 years. The 1964 earthquake is a worst-case scenario. However, M7-8 events are possible. One unknown with regard to earthquake hazards in KEFJ is the existence of other faults.

About three-fourths of the deaths from the 1964 earthquake were tsunami related. Tsunamis are generated in two ways: 1) fault movement, as in the recent Indonesia tsunami, and 2) underwater landslides, or slumps, as in the 1964 earthquake. Tsunamis caused by fault movement are far-traveled. Coastal Alaska is a perfect geologic environment for producing slumps because of the steep coastline.

The 1964 slides near Seward are clearly imaged. Work with NOAA in 2005 will attempt to seismically image the blocks.

In LACL, the Lake Clark fault is an important strike-slip fault. The fault is along strike from the active Castle Mountain fault. An aeromagnetic map of the Lake Clark fault shows an offset of 26 kilometers. Average slip along the fault is about 1 mm/yr, and the fault trace correlates with a belt of about 36 Ma intrusions.

Peter also presented KEFJ as a world-class example of a Paleocene-Eocene (61-50 Ma) slab window (termed "ridge subduction" in the old literature). Slab windows form at triple plate junctions, most commonly at Trench-Ridge-Trench (T-R-T) triple junctions. Peter presented a model with a series of illustrations from 85 Ma to the present showing how a slab window forms. Evidence in southern Alaska for a T-R-T triple junction and subsequent slab window include near-trench granitic plutons, high pressure/low temperature areas, the Nuka Bay lode gold deposits that map a diachronous age trend, and the Resurrection Peninsula ophiolite sequence (pieces of oceanic crust).

Lake Level Change in Large Lake Systems: Implictions for Interpreting Records of Salmon History in LACL – Iliamna Region, Alaska

Patricia Heiser, University of Alaska, Anchorage (UAA), uses lake level change to help reconstruct the paleo-environment and paleo-landscape. Mapping deltas, beach ridges, and paleo-channels can identify areas in which to look for cultural resources – if salmon were there, people might have been, also. Several lines of evidence such as alder changes, geochemistry variations, tephra levels, beach terraces, and dating the contact between lake clay and organics in cores can help determine lake levels.

Data from Trikakila Lake indicate ice out by 12,000 years BP. Evidence from Tommy Lake, one of the high control lakes used for control of deglaciation, suggests that ice was out of the valley 15,330 years ago. Lily and Olga lakes were just above lake level from15,000-11,000 years BP. Research continues in KATM and LACL.

Discussion of lake levels and revisiting LACL led to the need for park personnel in the field to be able to know what features need dating, how to sample, and where to sample.

The meeting was adjourned at 3:34 pm on Thursday, February 17, 2005.

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NAME	AFFILIATION	TITLE	PHONE	E-MAIL
Beavers, Rebecca	NPS-GRD	Coastal geologist	303-987-6945	rebecca_beavers@nps.gov
Bennett, Alan	NPS-SWAN	Network coordinator	907-644-3681	alan_bennett@nps.gov
Bundtzen, Tom	Pacific Rim Geological Consulting	Geologist	907-458-8951	bundtzen@mosquitonet.com
Connors, Tim	NPS-GRD	Geologist	303-969-2093	tim_connors@nps.gov
Covington, Sid	NPS-GRD	Geologist	303-969-2154	sid_covington@nps.gov
Cusick, Joel	NPS-AKRO	GIS specialist/LACL	907-644-3549	joel_cusick@nps.gov
Dickson, George	NPS-AKRO	GIS team manager	907-644-3546	george_dickson@nps.gov
Fiorillo, Tony	Dallas Museum of Natural History	Curator	214-421-3466 x234	tfiorillo@dmnhnet.org
Giffen, Bruce	NPS-AKRO	Geologist	907-644-3572	bruce_giffen@nps.gov
Graham, John	Colorado State U.	Geologist	970-225-6333	rockdoc250@comcast.net
Griffiths, Lynn	NPS-AKRO	Geological engineer	907-644-3573	lynn_griffiths@nps.gov
Haeussler, Peter	USGS	Geologist	907-786-7447	pheuslr@usgs.gov
Hall, Shelley	KEFJ	RM chief	907-224-7539	Shelley_hall@nps.gov
Halloran, Jim	NPS-ARO-NRST	Geologist	907-644-3574	Jim_Halloran@nps.gov
Heiser, Patricia	UA - Anchorage	Assistant professor - Geology	907-786-6854	pheiser@uaa.alaska.edu
Kozlowski, Janis	AKRO	RM specialist	907-644-3447	janis_kozlowski@nps.gov
Matt, Colleen	LACL	NR chief	907-271-1548	colleen_matt@nps.gov
Miller, Amy	NPS-SWAN	Ecologist	907-246-2123	amy_e_miller@nps.gov
Miller, Joe	NPS-SWAN	Fishery biologist	907-458-8951	joe_miller@nps.gov
Mortenson, Dorothy	NPS-SWAN	Data manager	907-644-3684	dorothy_mortenson@nps.gov
Mow, Jeff	KEFJ	Superintendent	907-224-7515	Jeff_Mow@nps.gov
Neal, Tina	USGS-AVO	Geologist	907-786-7458	tneal@usgs.gov
Piercy, Joni	NPS-AKRO	GIS specialist	907-644-3554	joni_piercy@nps.gov
Pinamont, John	NPS-AKRO	GIS specialist	907-644-3555	john_pinamont@nps.gov
Rice, Bud	NPS-RER	Environment prof. specialist	907-644-3530	Bud_Rice@nps.gov
Schaefer, Janet	Alaska Division of Geological & Geophysical Surveys/AVO	Geologist	907-451-5005	Janet_Schaefer@dnr.state.ak.us
Stromquist, Linda	NPS-AKRO	Geologist	907-644-3576	linda_stromquist@nps.gov
Tetreau, Mike	KEFJ	RMS	907-224-7546	mike_tetreau@nps.gov
VanderHoek, Richard	DNR/Parks/Office of	Archaeologist	907-269-8724	richard_vanderhoek@dnr.state

	History & Archaeology/U. of Illinois			
Wesser, Sara	NPS-AKRO	I&M coordinator	907-644-3558	sara_wesser@nps.gov
Wilson, Frederic (Ric)	USGS	Geologist	97-786-7448	fwilson@usgs.gov